OIL ADSORPTION:

A Method for Determining the Affinity of Skin to Adsorb Oil from Aqueous Dispersions of Water-Dispensable Oil Preparations

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During the past 3 years there has been renewed interest in the use of bath oils for the treatment of generalized dermatoses—principally those associated with dryness and pruritus.

In 1958, Knox, Everett, and Curtis (1) described superior water-dispersible bath oils and this apparently stimulated various pharmaceutical companies into developing and making commercially available similar products combining either mineral or vegetable oils with non-ionic emulsifiers.

The objective of adding oils to the bath is the deposition of an emollient film over the entire skin. How effective are water-dispersible oils in this regard? How much of the added oil is adsorbed by the skin? What factors, such as concentration of oil in the bath water, duration of soaking in the bath, temperature of the bath and finally, the type of oil used can influence adsorption by the skin? The object of the investigation as reported here is to try to answer as many of these questions as possible.

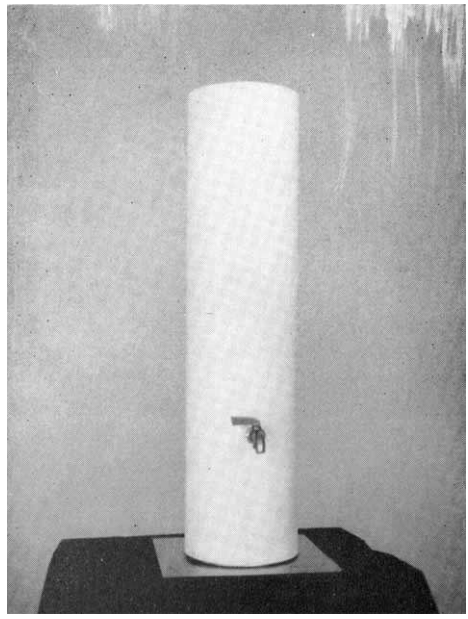

Fig. 1. Arm Immersion Cylinder

METHOD AND MATERIALS

Two spherical, stainless-steel cylinders, 56 cms tall x 14 cms diameter, equipped with petcocks to facilitate withdrawal of samples were employed as arm-immersion chambers (Figure 1). The cylinders were charged with 6000 grams of tap water. The preparations to be tested were added to the water and uniformly dispersed by stirring for 5 minutes with an air stirrer. These were added at such concentration that the resulting oil and water mixture contained 1.5 grams of oil per 6000 grams of water.

Three commercially available oils were used:

1. A combination of mineral oil, a lanolin fraction and polyethylene glycol laurate dispersant designated in this report as "mineral oil type".

2. A combination of cottonseed oil and octyl phenoxyethanol dispersant—designated in this report as "vegetable oil type".

3. A combination of colloidal oatmeal with 35% mineral oil and lanolin—designated in this report as "oatmeal-oil type".

The tests were conducted as follows: The subject immersed his arms into the dispersion cylinders. Necessary height adjustments were made so that immersion up to the elbows resulted. Five hundred gram samples of the dispersion were taken after soaking for from 10 to 30 minutes in the following manner: the subject removed his forearms from the cylinders, the mixture was stirred for one minute with the air stirrer and a 500 gram sample was withdrawn through the petcocks. The forearms were reimmersed subsequent to each sample withdrawal.

The analytical procedure employed was as follows:

1. The sample bottle with sample was weighed.

2. The sample was transferred into a 1-liter separatory funnel equipped with a teflon stopcock.

3. The cylinder was rinsed with 3 successive 50-ml. portions of ethyl ether, each rinsing being transferred into the separatory funnel containing the sample.

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4. The sample was shaken in a separatory funnel for two minutes. It was then allowed to stand until two distinct layers resulted. This usually required 10-15 minutes.

5. The aqueous portion was withdrawn into a second separatory funnel and set aside for additional extractions.

6. The ethereal portion was filtered through Whatman #40 paper into a tared 125 ml. erlenmeyer flask set on a steam bath, and the filtration rate was so adjusted that the flask was never more than one-third full of filtrate to avoid loss by "bumping".

7. Two additional extractions were carried out on the aqueous portion in the manner described. In all, 450 ml. of ether were used to extract each sample.

8. The residue in the erlenmeyer flask was dried to constant weight at 105–110°C.

RESULTS

Results are expressed as grams of oil adsorbed by the skin. This method permits comparison of adsorption of the same oil under various experimental conditions and also makes possible a simultaneous comparison of two different bath oils—one is dispersed in the right arm cylinder and the other in the left arm cylinder.

Table 1 presents assay results during "dry runs", that is, without arm immersion. This was done to insure that loss of oil from the water dispersion was not due to its adhering to the walls of the cylinder. As can be seen, the maximum deviation from the theoretical is about 4%, which can be considered within the experimental error to be expected in this type of assay. Whatever loss is measured during immersion must represent oil adsorbed by the skin.

Table 2 compares oil adsorption by the right arm with that of the left arm. The experimental conditions were the same. Three grams of oil were added to 6 liters of water in each cylinder. Arm immersion was for 15 minutes. The bath oil used was the "mineral oil type". Incidentally, unless mention is made to the contrary, the experiments were all conducted under these uniform conditions.

Thirteen subjects were tested. Normally expected differences were noted in oil adsorption between the right and left forearms of the same subject. However, the averages of the 13 subjects are in good agreement, viz., 1.25 grams

TABLE 1

Control assays—no subject used

(Results—milligrams per liter)

Time in Minutes	"Mineral Oil Type"	"Vegetable Oil Type"	"Oatmeal-Oil Type"
0	250*	262*	230*
10	257	263	233
20	254	258	233
30	257	261	239

* Theoretical oil concentration = 250 Mgs./Liter.

TABLE 2

Right arm versus left arm, 15 minutes immersion, "mineral oil type"

Subject	Grams Oil Adsorbed*	
	Right arm	Left arm
1	1.08	1.09
2	1.54	1.05
3	1.41	1.36
4	1.86	1.67
5	1.80	2.00
6	1.14	1.38
7	1.12	0.87
8	1.12	1.47
9	0.79	0.70
10	1.57	1.20
11	0.83	0.99
12	0.78	0.81
13	1.20	1.09
Average	1.25	1.21

* 3 grams oil added to 6 liters.

TABLE 3

Effect of temperature on oil adsorption

Subject	Left arm 84–88°F.	Right arm 102–106° F
1 (a)	1.41	1.81
(b)	1.39	1.71
2 (a)	0.76	0.99
(b)	0.68	0.94
3 (a)	1.26	1.39
(b)	1.26	1.43
4 (a)	1.17	1.26
(b)	1.18	1.46
Average	1.14	1.37

adsorbed by the right forearm and 1.21 grams by the left forearm.

The results indicating effect of temperature on oil adsorption are presented in Table 3. It appears that increasing temperature results in greater oil adsorption as evidenced by average values of 1.14 grams adsorbed at 84–88° F. and 1.37 grams at 102–106° F.

Length of immersion time was varied in an attempt to establish relationship between time and amount of oil adsorbed. From the data presented in Table 4, it appears that very little is gained by increasing the immersion time longer than 15–20 minutes.

Table 5 clearly shows that the greater the concentration of oil in the water dispersion, the more oil the skin adsorbs. At a concentration of 0.25 grams per liter, adsorption of oil is only one-third that at 4 times the concentration.

TABLE 4

Effect of immersion time on oil adsorption

Subject	Immersion Time Minutes	Grams Oil Adsorbed	
		Right arm	Left arm
A. 10 minutes vs. 20 minutes			
1	10	1.28	1.21
	20	1.41	1.36
2	10	0.98	0.89
	20	1.14	1.38
3	10	1.03	0.98
	20	1.12	1.47
Average	10	1.06	
	20	1.31	
B. 15 minutes vs. 30 minutes			
4	15	1.46	0.92
	30	1.54	1.05
5	15	0.86	0.61
	30	1.12	0.87
Average	15	0.96	
	30	1.15	

TABLE 5

Effect of oil concentration on adsorption

Subject	Grams Oil Adsorbed	
	Right arm 1.0 gm/l	Left arm 0.25 gm/l
1 (a)	2.27	0.92
(b)	2.25	0.52
2 (a)	1.06	0.39
(b)	1.85	0.52
3	1.67	0.74
Average	1.82	0.62

TABLE 6

"Mineral oil type" versus "vegetable oil type" preparation

Subject	Grams Oil Adsorbed	
	"Mineral oil type"	"Vegetable oil type"
1	1.74	0.66
2	1.59	1.28
3	1.46	0.71
4	1.67	1.45
5	1.05	0.37
6	1.35	1.32
7	1.14	0.59
8	1.14	1.03
9	1.29	0.67
10	1.05	0.74
11	1.05	0.33
12	0.81	0.51
Average	1.29	0.80

TABLE 7

"Mineral oil type" versus "oatmeal-oil type" preparation

Subject	Grams Oil Adsorbed	
	"Mineral oil type"	"Oatmeal-oil type"
1	1.14	None
2	1.27	0.39
3	0.75	None
4	0.98	0.37
5	0.73	0.12
6	0.77	0.21
7	0.84	0.18
8	0.62	0.44
9	0.93	0.52
10	1.21	0.48
11	1.40	0.52
12	0.89	0.36
Average	0.96	0.30

Table 6 compares skin adsorption of "mineral oil type" bath oil against that of a "vegetable oil type" bath oil. In 12 experiments adsorption of the "mineral oil type" product was 1.29 grams while that of the "vegetable oil type" was 0.80 grams, a difference of more than 50 per cent.

Table 7 shows an even more surprising comparison—that of "mineral oil type" against "oatmeal-oil type" bath oils. In 12 experiments the average adsorption for the "mineral oil type" product was 0.96 gram in contrast to 0.30 gram for the "oatmeal-oil type".

DISCUSSION

The results suggest the following observations.

1. Under suitable conditions, the skin can adsorb as much as 50% of the oil contained in a water dispersible oil mixture.

2. Very little is gained by having the skin immersed for periods longer than 15–20 minutes.

3. The amount of oil adsorbed appears to be a function of concentration.

4. The most striking results observed during this study are the large differences in the amount of oil adsorbed from aqueous mixtures employing three different commercially available products. The "mineral oil type" product deposited at least twice as much oil on the skin as did the "vegetable oil type".

A possible explanation of this difference is suggested by Goldenberg (2) who observed that small amounts of mineral oil in shampoos are adsorbed by the hair, "beyond reasonable expectations", despite the excellent emulsifying properties of the surfactants in the shampoo.

The "oatmeal-oil type" product was adsorbed very poorly by the skin. A possible explanation is that finely pulverized oatmeal adsorbs mineral and lanolin oils better than the skin does.

Data on whole body immersion experiments are being obtained and will be reported on at a later date. These are being conducted on subjects with normal skin, patients with ichthyosis, atopic dermatitis, and with psoriasis. Perhaps these studies will help to establish the value of balneotherapy employing water-dispersible oil preparations, a subject of some controversy among dermatologists.

SUMMARY

A method for determining comparative adsorption of oils by the skin, from water-bath oil dispersions is described.

Comparison between right arm and left arm adsorption is possible only when made simultaneously, since day to day variations are quite appreciable.

Periods of soaking longer than 20 minutes do not appear to cause significant increase in oil adsorption.

Adsorption apparently increases as temperature of the bath is raised. Adsorption is greater when the concentration of oil is increased.

"Mineral oil type" bath oils are adsorbed better than "vegetable oil type" bath oils. Adsorption of "oatmeal-oil type" bath oils is very poor, probably because of affinity of finely pulverized oatmeal for the oils incorporated in it. The clinical significance of these differences in cutaneous oil adsorption has not been established.

REFERENCES

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